Chapter 1

Introduction

Stereo vision is an imaging technique that can provide full field of view 3D measurements in an unstructured and dynamic environment. The basic of stereo vision are similar to 3D perception in a human vision and is based on triangulation of rays from multiple viewpoints.[6] Each pixel in a digital camera collects the light that reaches the camera along a 3D ray. If feature in the world can be identified as a pixel location in an image then this feature lies on the 3D ray associated with that pixel. If multiple cameras are used multiple rays are obtained. The intersection of these rays is the 3D location of the feature.

The key problem to solve stereo vision are to identify which pixel in multiple images match the same world feature .This problem is known as stereo matching or stereo correspondence. Stereo Matching is for a given two or more images of the same scene or object, compute a representation of its shape. Stereo Matching is process of finding disparity or depth information.[10]

The tracing of corresponding phenomena i.e. stereo matching is necessary key funtionality in many applications like image sequence analysis in entertainment, information transfer and automated systems. Stereo matching is highly important in fields such as robotics to extract information about the relative position of 3D objects in the vicinity of autonomous systems. Other applications for robotics include object recognition, where depth information allows for the system to separate occluding image components, such as one chair in front of another, which the robot may not be able to distinguish as a separate object by any other criteria.

Scientific applications for digital stereo vision include the extraction of information from aerial surveys, for calculation of contour maps or even geometry extraction for 3D building mapping, or calculation of 3D heliographic information such as obtained by the remote sensing projects of the ISRO .

There are many algorithms for stereo matching have been proposed, the computation of disparity still remains challenging in texture less regions, depth discontinuities and occluded areas. The stereo algorithms can be roughly categorized into three classes.[12]

The first class is the area-based algorithms. These algorithms attempt to correlate the gray levels of pixels within a finite neighboring window. A central problem of the area- based algorithms is to find the optimal size of the window. While the window size must be large enough to include enough intensity variation for matching, it must be small enough to avoid the effects of projective distortion. The second class is the feature- based algorithms. They extract features of interest from the image, such as edges, and match the features. The disadvantage of the feature-based algorithms is that they usually yield

sparse disparity maps. The third class global algorithms such as dynamic programming, graph cuts and belief propagation use global constrains over the entire image. Global algorithms can deal with the texture fewer regions and occluded regions well they performed over the whole images.
In spite of having advantages of global algorithm, there have been few real time stereo matching implementations due to their high complexity. Among global algorithm, dynamic programming can be used to implement real time systems but is not robust since it doesn't consider vertical consistency[33] The stereo matching problems can formulate in terms of Markov Random Field as minimum energy function, to find energy minimization function is NP-hard. This means a general solution to this problem will take an unthinkably long time to reach a solution.
Belief propagation algorithm is an approach which find the approximate solution for minimum energy functions used for stereo matching.[1] Belief propagation algorithm considers both vertical and horizontal consistency is most robust method in the presence of texture less regions and occlusion .
However,Even Belief propagation is computationally complex and often it implementation in real time is not possible. Current research is directed towards optimizing the BP algorithms and associated hardware for fast implementation.

Chapter 2

Literature Review

Some of the major contributions in the optimization of BP streo matching are as follows:
Chia-Kai et.al[1] used Loopy Belief Propagation(LBP)with simple message update process to iteratively refine the beliefs of labels and showed that it could be effectively applied to the problems like stereo matching, Image de-noising etc..

Pedro F.Felzenszwalb and Daniel P.Huttenlocher [2] used to find cost function by using distance transform technique ,grid graph and perform BP in a coarse to fine method for solving early vision problem
Li Zhou et.al[3] surveyed about optimization potential for both stereo matching algorithm optimization and software or hardware implementation in terms of speed, parallelism, data bandwidth, memory storage, etc. The Graphic Processing Unit (GPU), Field Programmable Gate Array (FPGA) and Application-Specific Integrated Circuits (ASIC) designs are future research trends in real time embedded stereo vision application systems because of their high parallel processing capabilities and specific powerful calculation supporting components.
Young-kyu Choi et.al[4] used reducing number of pixels (i.e. reduction in spatial domain) approach is used to reduce data size and transfer bandwidth is significantly reduced by storing only a part of the whole message to optimize the BP. In order to maintain the accuracy, the local messages are reconstructed by taking advantage of the shared memory available in Graphic Processing Units (GPU)
Chi-Hua Lai et.al[5] used parallelization of a belief propagation algorithm on the multicore processors have proposed. The methods used to demonstrate the issues in optimizing the algorithm by exploiting the potential parallelism to expose the architecture benefits. The methodology of analyzing and exploiting parallelism presented in this article is applicable to other stereo vision algorithms.
Eduardo.M et.al[6] developed belief algorithm using functional VHDL hardware description language and is technology-independent. So, the system can be implemented on any large enough FPGA
Yu-Cheng Tseng et.al[16] used to partitions an image to block and optimizes with belief propagation which reduces the memory size. The block based approach discontinuous disparities region occurs in the boundary of edges which can enhance the interaction between neighboring blocks such that the independent block could extract useful information from the neighboring finished processing block.
Radu Timofte et.al[8] used Four-Color Theorem technique for Belief propagation based on the max-product for solving early vision problems such as MRF problems where energy

is to be minimized
Nama et.al [9] used method task scheduling which is more suitable tool for Parallel implementation of Belief Propagation in Factor Graphs a task dependency graph for belief propagation and then using a dynamic task scheduler to exploit task parallelism available in the task dependency graph.

Problem Definition: It is proposed to work on the algorithm optimization and fast implementation of Belief Propagation algorithm without much degradation in accuracy

Research Design:

1. Study the implementation of stereo matching using Belief Propagation and understands the issues in implementation. Study different techniques to optimize belief in different approaches

2. Try to evolve a new approach considering hardware and software implementation in Belief Propagation

Expected Results:

Development of a new/modify Belief Propagation optimization method for stereo matching application/cases of stereo matching. Comparative study of the new method with existing methods.

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